III-13.01 Introduction

These design procedures should be used after it has been determined that guardrail is warranted. Standards D-764-1 through D-764-37 should be used to determine the length of need and location of the guardrail and post spacing. These Standards can be found on www.@.state.nd.us under Design Division Standards. The design procedures should be used to determine the type of guardrail, the length of guardrail, and the position of the guardrail. The ROADSIDE DESIGN GUIDE has been used for guidance in preparing these design procedures.

III-13.02 Design Speed

The design speed should be determined according to the roadway classification. Generally, there are five classifications of roadway; 1) Rural Interstate; 2) Interregional System; 3) State Corridor; 4) District Corridor, and 5) District Collector.

The design speed should be obtained from Section I-06.

III-13.03 Lateral Clearance

The lateral clearance from the roadway centerline to the edge of the obstacle should be determined.

The distance from the finished shoulder to the roadway centerline should also be determined. For new surfacing projects, this distance should be determined from the typical section for the new surfacing. This should be obtained from the designer of the surfacing project. For other projects, the project designer in the responsible Roadway Design Section should be consulted.

III-13.04 Obstacle Type

There are several different types of obstacles. The type of obstacle will determine the type of guardrail to be used. Some of the different types of obstacles are as follow:

III–13.04.1 Bridge Rail Ends

These are near the roadway and should be treated with W-beam guardrail. The bridge rail should be an acceptable type of design and should have been crash tested in accordance with NCHRP Report 350.

The following types of bridge rail are acceptable and should have an acceptable end treatment for guardrail to bridge end connection:

A. **Jersey Barriers.** The Jersey barrier bridge rail should have the W-Beam Guardrail attached to the bridge rail using the standard W-Beam Terminal Connector and

transitioning to the standard W-Beam as shown on Standard Drawing D-764-3. The first 20 feet off the bridge shall have a 6 inch curb transitioning to match the bridge rail and sloped down to the pavement at the 20 foot end. Where a bridge approach slab is placed the bridge division will provide the curb on the slab.

If no approach slab is to be place, the guardrail designer will place.

B. **Sloped Curb.** The sloped curb bridge rail should be retrofitted and a thrie beam connector plate for transition from the retrofit bridge rail to the thrie beam. Standard Drawing D-764-3A shows the details for the thrie beam transition.

1. Bridge Rail Retrofit: The retrofit bridge rail should have a Thrie Beam terminal connector plate for transition from the retrofit bridge rail to the thrie beam connector. A 12' 6" Thrie Beam, with a Thrie Beam to W-beam transition section, is installed between the Thrie Beam connector and the W-beam approach rail. These sections should be doubled up. The Thrie Beam to W-beam transition and connection details are shown in Standard Drawing D-764-3A.

III-13.04.2 Light Standards. These are usually made breakaway by providing a slip base or a frangible transformer base. High mast poles are usually placed far outside the clear zones (100 feet or more from the edge of the roadway) of the particular highway and need no safety treatment. Guardrail warrants would be determined by clearances between driving lane and the pole locations. The offset distance requirement will be discussed later in this design procedure.

III−13.04.3 Utility Poles. These are placed far outside the clear zone of the particular highway. Guardrails for any of these poles that are not outside the clear zone will be discussed later.

III−13.04.4 Bridge Piers. These may be placed within the clear zone and may need guardrails. The type of guardrail will depend on the offset distance between the guardrail and the pier. The type of guardrail required is discussed in III−13.05.2.

III−13.04.5 Sign Supports. Sign supports are made breakaway or are a yielding type, except overhead sign structures. The overhead sign structures are treated like piers and will be discussed later.

III−13.04.6 Culverts. A safety review should be made of culverts 36 inches in diameter and larger that are within the clear zone. From the study, it should be determined if guardrail or culvert extension are cost effective. The type of guardrail will depend on the offset distance between the guardrail and the top of the culvert opening.

III−13.04.7 Water: Water is considered an obstacle if it is 2 feet deep and within the clear zone. In most cases, 3-cable guardrail is used.

III−13.04.8 Trees: Trees over 4 inches in diameter within the clear zone should have guardrail if they cannot be removed. The type of guardrail will depend on the offset from the guardrail.

III−13.04.9 Rock or Rip rap. Rock or rip rap within the clear zone should be removed or moved outside the clear zone. If they cannot be removed or moved, guardrail should be installed. The type of guardrail will depend on offset from the guardrail. In some instances where there is insufficient room to install guardrail because of a narrow roadway width, it may be necessary to post the area for reduced travel speed.

III−13.04.10 Steep Slopes. Steep slopes are studied during the safety review to determine if guardrail or flattening the slopes is cost effective. When guardrail is required, 3-cable guardrail is used unless there is another obstruction on the foreslope that is within 11 feet of the guardrail in which case W-Beam is required.

III-13.05 Treatment of Obstacle

III−13.05.1 Bridge Rail Ends. The clear roadway distance is obtained from the bridge plans. The bridge plans will also show the type of bridge rail that is in place. The two types of acceptable bridge rail have been specified hereinbefore.

3. **Barrier Rail (Jersey Barrier Rail).** This type of rail requires a transition as shown on Standard Drawing D-764-3.

    a. The W-Beam bolted to a W-Beam Terminal Connector which is bolted directly to Bridge Rail as shown on Standard Drawing D-764-3. If a curb is incorporated into the bridge approach slab, the bridge plans will show if the bridge approach slab has the curb installed.

        (1). If a bridge approach slab has the curb incorporated into it, the bridge division will provide the necessary quantities for the curb.

        (2). Where there is no approach slab in place, a curb and gutter will be provided, and a curb shall be installed as shown on Standard Drawing D-764-3. The guardrail designer should provide the curb quantity.

            (a). When drainage is provided, using a drop inlet, the inlet shall be placed beyond the approach slab if approach slab is installed.

            (b). Drainage should be routed to the end of the approach slab and into a drop inlet which is beyond the guardrail. The method of transferring the water from the drop inlet down the foreslope will be underground. No curb shall be placed in front of the guardrail.

(3). When no approach slab is in place, and curb and gutter is in place, the curb and gutter should be removed. When drainage is provided for by using drop inlets, the inlets should be treated as in 2 (b).

(a) If the district requests that the curb and gutter be retained for drainage, the curb and gutter beyond the approach slab, shall have a 4" high (or lower) curb and gutter or a mountable curb 4" or less in height.

(b) Another method of providing drainage away from the approach slab end behind the guardrail would be to use a low asphalt curb at the edge of the pavement behind the guardrail to carry the water away from the bridge and into a drop inlet .The method of transferring the water from the drop inlet down the foreslope will be under ground.

4. **Bridge Rail Sloped Curb.** The Bridge Division will provide a retrofit bridge rail. The approach rail for the retrofit bridge rail should start with the Thrie Beam connector attached to the attachment plate on the retrofit bridge rail. A 12'-6" Thrie Beam is attached to the Thrie Beam connector using splice bolts. The post spacing on this section of Thrie Beam is 1'-1 3/4"except the last space before transition to W-Beam is 3' - 1 ½" and the Thrie Beam should be double thickness. The next section is a 6'-3" Thrie Beam to W-beam transition section with a post spacing of 3'-1½" and is also double thickness. For details, see Standard Drawing D-764-3A "Thrie Beam to W-beam Transition Connection." The Thrie Beam to W-beam transition section is connected to the Thrie Beam and W-beam with splice bolts.

5. Bridge rails may have to be updated temporarily by placing retrofit bridge rail.

a. The retrofit bridge rail plans should be prepared by the Bridge Division. The retrofit has an attachment plate to accommodate a Thrie Beam connector.

b. The approach rail for the retrofit bridge rail should start with the Thrie Beam connector attached to the attachment plate on the retrofit bridge rail. A 12'-6" Thrie Beam (double thickness) is attached to the Thrie Beam connector using splice bolts. The post spacing on this section of Thrie Beam is 1'-1 3/4"except the last space before transition to W-Beam is 3'-1 ½". The next section is a 6'-3" Thrie Beam to W-beam transition section with a post spacing of 3'-1½" and is also double thickness. For details, see Standard Drawing D-764-3A "Thrie Beam to W-beam Transition Connection." The Thrie Beam to W-beam transition section is connected to the Thrie Beam and W-beam with splice bolts.

6. **Bridge End Treatments with speeds under 30 mph.**

   a. The type of bridge rail will determine what is required.

      (1). At speeds of less than 30 mph and a bridge rail is in the shape of a jersey barrier, the approach end would be a blunt end. If an errant vehicle where to hit this at less than 30 mph it could cause severe injuries and even death. Therefore, we will provide a 20 foot + or minus long wall that transitions from the height of the bridge rail barrier down to a curb and if no curb exists to a height of 4" or less. This treatment was recommended by the FHWA when speeds are less than 35 mph.

      (2). When the bridge rail treatment meets NCHRP Report 350, such as the retro-fit we use, there is no acceptable end treatment. We suggest that the thrie beam connection and a transition to the W-Beam and then a standard end treatment be used. These are shown in our Standard Drawings D-764-3A, D-764-2B, and D-764- 2C.

   Another question is can we reduce the speed down to 25 mph and have no guardrail or less guardrail. If the prevailing speeds at the bridge are greater than 45 mph there should be no reduction of speed to eliminate guardrail. The motorists will not understand why the reduced speed is in place and the motorists will travel at the speed that is reasonable.

III–13.05.2 Bridge Piers. Bridge piers that are within the clear zone should have guardrail. The type of guardrail will depend on lateral clearance from the guardrail to the piers.

1. When piers are less than 1'-3" from the finished shoulder, a Jersey type barrier should be placed directly against the pier, and the Jersey barrier should run from outside of the pier to outside of the pier and be 42" in height. The Jersey barrier should then transition down in 10' to the height of 32 inches. An addition 2 feet of 32-inch high barrier shall be provided. A curb and gutter shall be installed on the approach end of the Jersey barriers as shown on Standard Drawing D-764-3. The W-Beam is bolted to a W-Beam Terminal Connector which is bolted directly to Jersey barrier as shown on Standard Drawing D-764-3. On non-divided roadways, a curb and gutter shall be placed in both directions. See Figures 1-2 in Appendix III-13 A. The W-Beam is bolted to a W-Beam Terminal Connector which is bolted directly to Jersey barrier as shown on Standard Drawing D-764-3.

2. When bridge piers are between 1'-3" and 3' from the finished shoulder, W-beam guardrail should be used. The post spacing of the W-beam should be reduced to 3'-1½" from 25' in advance of the piers and past the pier area. The last section beyond the piers should have 6'-3" post spacing and a breakaway cable treatment should be used on this 6'-3" post spacing section. See Figure 17 , Appendix III–13 A

3. When bridge piers are 3' to 11' from the guardrail, W-beam guardrail should be used with 6'-3" post spacing throughout. The last 6'-3" post spacing past the pier should have a breakaway cable treatment. See Figure 17, Appendix III-13 A.

4. When piers are over 11' from the finished shoulder, 3-cable guardrail should be used because of reduced installation cost and reduced snow accumulations.

   The 3-cable guardrail should be placed 9' from the driving lane on the median side of divided roadways as long as the 11' or more clearance can be maintained. The 3-cable guardrail should be placed at a slope of 10:1 or flatter when placed in this position. The 10:1 or flatter slope should be carried 3' beyond the guardrail. The area outside the 10:1 slope should be graded to drain away from the piers. Some culvert extension or installation may be needed.

5. Where there are median piers and both roadways are at nearly the same elevation, one of the following treatments should be installed:

   1. Where piers are set on top of a rectangular footing the top of which is at least 42 inches above the existing ground:

      The median should be filled to provide a flat area from the face of the impact attenuator outward toward the roadway a distance of five feet. From this point the fill should be on a 12:1 slope to the finished edge of the shoulders.

      42 inch high and 12 foot long transition walls will be constructed on each end of the pier footing. The walls will transition from 42" to 32" high in 10 feet and requires an additional 2 feet of wall at 32" high above the finished flat area. The barrier walls and transitions shall be reinforced.

      A Terminal Impact Attenuator crash cushion meeting the test requirements of NCHRP Report 350 (TL3) will be installed on a concrete slab. The concrete slab shall meet the requirements of the of the crash cushion manufacturer.

      See Figures 3–7 in Appendix III–13 A.

   2. Where piers are set on footings below the ground:

      The median shall be filled to provide a flat area from the face of a Jersey barrier wall, that is placed against the piers, outward toward the roadway a distance of five feet. From this point the fill should be on a 12:1 slope to the edge of the finished shoulders.

A 42" high jersey barrier will be placed from end of pier to end of pier on both sides of the piers. The 42" high Jersey barrier will be transitioned to 32" high, the distance will vary. The top width of the Jersey barrier face (at the pier) shall be tapered to 1' 8" at a 1:20 slope at the point where the beginning of the attenuation device backup will be installed. At this point the top of the Jersey barrier shall be transitioned to a rectangle 2' wide and 32" high.

The barrier walls and transitions shall be reinforced.

A crash cushion attenuator meeting the test requirements of NCHRP Report 350 (TL3) shall be installed on a concrete slab. The concrete slab shall meet the requirements of the crash cushion manufacturer.

See Figures 8-11 Appendix III–13 A

3. Where piers are set on footings below the ground:

The median shall be filled to provide a flat area from the end barrel, of the sand fill barrel attenuation device farthest from the Jersey barrier end, outward toward the roadway a distance of five feet. From this point the fill should be on a 12:1 slope to the finished edge of the shoulders.

A 42" high Jersey barrier will be placed from end of pier to end of pier on both sides of the piers. The 42" high Jersey barrier will be transitioned to 32 “high, the distance will vary. The top width of the Jersey barrier (at the pier) shall be tapered to 1' 8" at a 1:20 slope at the point where the beginning of the attenuation device back up will be placed. At this point the top of the Jersey barrier shall be transitioned to a rectangle 2' wide and 32" high above finished surface. The barrier walls and transitions shall be reinforced.

A sand fill barrel attenuation device shall be installed at a 10 degree angle toward traffic on a concrete or asphalt slab.

See Figures 12-16 Appendix III–13 A

III-13.05.3 Sign Supports. Sign supports usually are made of breakaway or yielding type material. In some cases, overhead sign structures are utilized and their end towers and foundations may need guardrails or have Jersey barrier and crash cushion placed when the end towers and foundations are within the clear zone. The overhead sign structure end tower and foundation should be guardrailed, or have Jersey barrier and crash cushion, when warranted, using the same criteria as used for bridge pier protection.

III−13.05.4 Culverts. The location of the culvert end openings will determine the type of guardrail. The same criteria used for piers will determine the type of guardrail to be used. Where Culverts can be extended out side the clear zone the length of the culverts can be reduced using the following method.

Culverts Lengths.

Culverts 18 inches and over need, have to have their openings out side the clear zone. Roadways having 1:4 fore slopes will require longer pipe lengths than 1:6 foreslopes because the clear zone for 6:1 foreslopes is less. Where culverts over 18 inches in diameter are to be installed or extended on roadways that have 1:4 fore slopes, the following method will reduce the length of the culvert.

The installation of culverts over 18 inch diameter shall be placed to outside the clear zone. In order to minimize the length of culverts, the foreslope can be flattened to 1:6 and provide a lesser length culvert than would be required for the steeper 1:4 foreslope.

An errant vehicle leaving the roadway can recover much easier on the 1:6 foreslope than on the steeper slope and if it is steeper than 1:3 it will likely roll over and reach the flat area at the bottom of the roadway fill. By flattening the foreslope at the culvert end when it is placed at or just beyond the clear zone and tapering this flattened back to where an errant vehicle leaves the roadway shoulder a driver will be able to return to the roadway prior to the culvert end hazard. The length of the taper is determined from the Suggested runout lengths for barrier design in the Roadside Design Guide as reproduce in the attached drawing (Figure 18).

The foreslope out side the 1:6 should be transition down to the ditch bottom using the foreslope in advance of the transition. Where there are high fills and the volumes are less that 750 ADT the slope may be steepened to 1:2 out side the clear zone. Remember that the clear zone for the 1:4 foreslope is larger than the 1:6 and therefore there must be a 1:4 transition before the foreslope 1:2.

Where the cover over the culvert is such that the fill must be flatter to less than 1:6, a transition from 25 feet prior to the culvert shall be transitioned from the flatter slope for the lesser cover to the approaching 1:6 slope. This transition shall be sloped at 1:10.

Box Culverts have wing walls of 1:2 slopes and the 4:1 slope will have to be transition to the 2:1.

For high fills and high volumes, the flatter secondary slope (1:24 12' wide should be placed. 20% of the errant vehicles leaving the roadway will go beyond the clear zone. Because the higher volumes will have many more vehicles and therefore the 20% will have higher numbers, this would provide these errant vehicles a recovery area prior to the steep foreslope.

High fills and high volumes are defined as over 10 feet high and over 2000 ADT. See appendix III-13A for Figure 18 for Details for design.

The culverts 15 to 30 inch diameters can be within the clear zone if they have a traversable end section. The details for traversable end sections can be found on the NDDOT web site www.@.state.nd,us under design manual, plan prep. Guide, drawings, section 700, 714, culverts.

III–13.05.5 Water. Water areas should have 3-cable type guardrail in most cases where the rip rap is outside the 11-foot deflection distance. W-Beam guardrail must be used from 3 to 11 feet.

III–13.05.6 Rock Outcroppings. The location of the obstacle will determine the type of guardrail to be used. The same criteria used for piers should be used.

III–13.05.7 Steep Slopes. Steep foreslopes warranting guardrail will normally require the use of 3-cable guardrail. Foreslopes 3:1 or steeper require guardrailing. Foreslope of steeper than 2:1 will require W-Beam guardrail because errant vehicle will go under the cables when they deflect near the 3-cable guardrail maximum deflection.

III–13.05.8 Bridge Ends, Culverts, or other Obstacles. These may require a combination of W-beam.

III-13.06 Guardrail Location

A. W-beam guardrail should be placed at bridge ends or barrier walls. The straight sections should be aligned with the face of the barrier wall or the flat plate of the retrofit bridge rail.

B. W-beam guardrail placed at other than bridge ends should be placed at the finished shoulders with the front face of the guardrail aligned with the finished shoulder. In no case should the slope in front of the W-beam guardrail be greater than a 10:1 slope. Where piers are close to the roadway, and a barrier wall is to be installed, the alignment should be as stated above for W-beam guardrail placed at bridge ends.

C. W-beam guardrail may be flared away from the roadway at the flare rate shown on the standard drawings, dependent on the design speed. In all cases, a curved section will transition the straight section to the flared section. The straight section for piers, culverts, rock outcrops, overhead sign structures, etc., should have a minimum of a 25' straight section prior to the obstacle.

D. W-beam guardrail locations may have field conditions that will not allow it to be flared. When conditions such as drainage and right of way will not allow the W-beam guardrail to be flared, W-beam guardrail should follow the shoulder to the end terminal and flared as shown on the standard drawings.

E. Box Beam guardrail should be placed at the finished shoulder with the front face of the guardrail aligned with the finished shoulder break. In no case should the slope in front of the Box Beam guardrail be greater than a 10:1 slope. The box beam guardrail shall have an NCHRP Report 350 end treatment and is only used on the interstate highways.

F. 3-cable guardrail should be placed 2' from the shoulder, but not closer than 2' inside the graded shoulder. On divided highways where piers are protected with 3-cable guardrail, the 3-cable guardrail should be placed 9' from the edge of the driving lane on the median side, but no closer than 11' from the face of the pier. In most cases, fill will be required for placement of the 3-cable guardrail at that point. The fill area between the finished shoulder and 3' beyond the 3-cable guardrail location should be 10:1 or flatter. Drainage may have to be modified for installation of the 3-cable guardrail at the 9' location. 3-cable guardrail will only be used in the median where the roadways top elevation of the two roadways differ to the extent that median protection using the footing for piers is 42 inches above the fill area or footing is below the fill area using Jersey barrier and attenuation device cannot be placed because the 1:12 on the roadway side and 5-foot flat area between the 1:12 slope and the Jersey barrier cannot be achieved.

III-13.07 Length of Need
III–13.07.1 Bridge End Treatment

1. The W-beam guardrail should be carried 51' -10 3/4" straight as shown on the layouts for the various design speeds shown on Standard Drawings D-764-5A through D-764-9. The end treatment should be one of those shown in Standard Drawings D-764-2B, C, or H . The type is the contractors option.

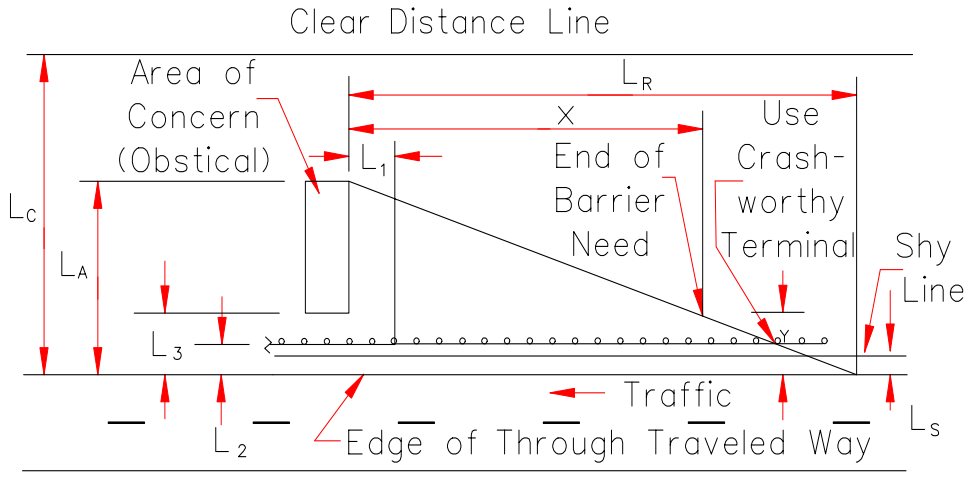
2. The bridge end connection will depend on the bridge rail. Barrier wall bridge rails should have the W-Beam bolted to a W-Beam Terminal Connector which is bolted directly to Jersey barrier as shown on Standard Drawing D-764-3.

3. When the retrofit bridge rail is installed, the straight section should begin on the bridge with the Thrie Beam terminal connector which attaches to the retrofit attachment plate. The Thrie Beam and Thrie to W-beam transition should be installed as shown on Standard Drawing D-764-3A. The straight section from the end of the bridge to the curved section shall be at least 45 -7 3/4".

4. When drainage or other constraints won't allow the W-beam guardrail to be flared and fill to be installed to provide for an area between the finished shoulder and 3' behind the guardrail with a 10:1 or flatter slope, the W-beam guardrail should be installed straight. The length of need should be determined by the traffic volume, design speed, bridge clear roadway, and clear zone.

The suggested runout length for barrier design, uses the following formula for non flared guardrail:

$$X = (L_A - L_2)/(L_A/L_R)$$



Where L_A is the clear zone because at most bridge structure, the bridge is crossing a hazard. L_2 is the clearance between the edge of the travel way and the guardrail. L_R is the runout length

Traffic Volumes (ADT)				
Design Speed	Over 6000 vpd	2000-6000 vpd	800-2000 vpd	Under 800 vpd
mph	Runout Length L_R ft	Runout Length L_R ft	Runout Length L_R ft	Runout Length L_R ft
75	550	465	425	375
70	475	445	395	360
65	450	420	370	345
60	425	400	345	330
55	360	345	315	280
50	330	300	260	245
45	260	245	215	200
40	230	200	180	165
30	165	165	150	130

When the bridge width from the centerline of the approach roadway is not symmetrical, such as on divided highways, the bridge width should be determined by taking two times

the distance from the centerline to the bridge rail. This width is used for the bridge clear roadway in determining the length of need used on that side of the roadway.

III−13.07.2 Obstacles

1. The treatment of the various types of obstacles will depend on the lateral clearance.

   a. Objects within 0 to 1'-3" from the roadway finished shoulder should have a barrier wall installed with the W-beam guardrail. The barrier wall should be from the approach end to the opposite end, or at other objects that rise above the wall, should have a wall 42" high. The wall should be transitioned down 32" high barrier wall in 10'. The barrier wall shall be reinforced. The length of need should be determined from Standard Drawings D-764-5A through D-764-9 for bridge ends.

      (1). On divided highways, the 42 inch barrier should be installed only to the end of the obstacle on the exiting end.

      (2). The W-Beam should be attached to the 32" barrier wall at both ends on two-way roadways and on the approach end on divided highways.

   b. Obstacles 1'-3" to 3' from the roadway finished shoulder should have the W-beam guardrail installed with the obstacle length plus 25' past the obstacle. The W-beam is reinforced by reducing the post spacing to 3'-1½".

      (1). The guardrail along the obstacle should have a length that is equal to the length of the obstacle plus the length required to make the length divisible by 12'-6". The total length should be symmetrical about the centerline of the obstacle.

      (2). The guardrail for divided highways should be in advance of the obstacle and one 12'-6" section beyond the obstacle. The 12'-6" section should have the breakaway cable treatment provided in the last 6'-3" post spacing anchored down to the last post. See Figure 17 Appendix III−13 A.

   c. Obstacles 3' to 11' from the roadway finished shoulder should have W-beam guardrail installed.

      (1). The guardrail along the obstacle should have the length calculated as specified in b(1) above.

      (2). The guardrail for divided highways should be as specified in b(2) above.

d. Objects over 13' from the roadway finished shoulder should have 3-cable guardrail installed.

(1). 3-cable guardrail should be placed 2' from the finished shoulder, but not closer than 2' to the graded shoulder. To ensure the 2' to the graded shoulder, the distance to the finished shoulder could be less than 2'.

(2). On divided highways where median piers are protected with 3-cable guardrail, the 3-cable guardrail should be placed 9' from the edge of the driving lane on the median side but no closer than 11' from the face of the pier. In most cases, fill will be required for placement of the 3-cable guardrail at that point. The fill area between the finished shoulder and 3' beyond the 3-cable guardrail location should be 10:1 or flatter. Drainage may have to be modified for installation of the 3-cable guardrail at the 9' location. 3-cable guardrail will only be used in the median where the roadways' top elevation of the two roadways differ to the extent that median protection using the footing for piers is 42 inches above the fill area or footing is below the fill area using Jersey barrier and attenuation device cannot be placed because the 1:12 on the roadway side and 5 foot flat area between the 1:12 slope and the Jersey barrier cannot be achieved.

III-13.08 Guardrail Design

The design of guardrail for a particular type of obstacle uses each of the above sections to obtain the proper design. The following information should be obtained for each location:

A. The designer should determine the type of obstacle.

1. Bridge ends: Obtain bridge rail plans.

2. Piers and bridge layout: Obtain bridge layouts and pier plans.

3. Culverts: Obtain plan and profile sheets.

4. Steep slopes: Obtain plan and profile sheets.

5. Water: Obtain plan and profile sheets.

6. Other: Obtain plan and profile sheets.

B. The designer should obtain the design speed for that section of roadway.

1. 40 mph

2. 50 mph

3. 60 mph

4. 65 mph

5. 70 mph

6. 75 mph

C. Lateral clearance from roadway centerline to obstacle should be determined. Obtain the cross sections of the roadway in the area guardrail is warranted.

D. The traffic volumes should be obtained from the plan title page or from the Planning and Programming Division.

III-13.09 Design Procedures

The following design procedures should be followed, dependent on the type of obstacle, using the above information:

III–13.09.1 Bridge Ends. The designer should use W-beam guardrail at these locations and the length of need should be obtained from Standard Drawings D-764-5A to D-764-9, dependent on design speed.

1. The type of bridge end treatment should depend on whether the bridge has barrier wall or retrofit railings.

2. **Barrier Wall**

   a. The barrier wall will need the curbs installed. It may be installed by incorporating it into the bridge approach slab, in which case the Bridge Division should design. The plans for the bridge approach slab should be obtained from the Bridge Division. If no approach slab is being installed by Bridge Division, the designer should provide the curb and gutter and Standard Drawing D-764-3 for details.

   b. **Bridge Rail Sloped Curb.** The Bridge Division will provide a retrofit bridge rail. The approach rail for the retrofit bridge rail should start with the Thrie Beam connector attached to the attachment plate on the retrofit bridge rail. A 12'-6" Thrie Beam is attached to the Thrie Beam connector using splice bolts. The post spacing on this section of Thrie Beam is 1'-1 3/4"except the last space before

transition to W-Beam is 3' - 1 ½" and the Thrie Beam should be double thickness. The next section is a 6'-3" Thrie Beam to W-beam transition section with a post spacing of 3'-1½" and is also double thickness. For details see Standard Drawing D-764-3A "Thrie Beam to W-beam Transition Connection." The Thrie Beam to W-beam transition section is connected to the Thrie Beam and W-beam with splice bolts.

3. **Bridge Rail Retrofit**

   a. The Bridge Division should provide an attachment plate to the end of the retrofit bridge rail to accommodate the Thrie Beam terminal connector. Where the retrofit is in place, the Bridge Division should make the modifications to provide the attachment plate. These plans should be "Thrie Beam to W-beam Transition and Connection to Double Box Beam Rail Retrofit".

4. The length of need is taken from Standard Drawings D-764-5A to D-764-9, dependent on design speed.

   a. Entering the table on the appropriate standard drawing with the bridge width and traffic volume, read across the standard drawing to determine the various guardrail dimensions for that bridge width and traffic volume.

   b. The bridge on a two-way roadway should have the length of guardrail shown on the approach side and opposite side. The guardrail should have the end treatment as shown on Standard D-764-2B, C or H. Dimension C on the standards drawings should be used.

   c. Where an approach falls within this length, the approach should be moved. The district office should determine if the approach can be moved.

   d. If the approach cannot be moved, the guardrail should be broken, with 51' -10 3/4" straight section and an end treatment as shown on Standard D-764-2B, C or H installed in the vicinity of the radius of the approach roadway as minimum. The guardrail length needed should be provided by placing a length of guardrail on the other side of the driveway to the required length, and an end treatment as shown on Standard D-764-2B, C, or H installed on both ends of the guardrail. The length of need shall include the end treatments minus the first 12.5 feet from the end of the terminal ends that may be hit by errant vehicles. The end treatment at the approach should begin at a point 5 feet from the vehicle turning radius. The end treatment shall have the offsets as shown on the standard drawings.

On low-volume, low-speed roadways a curved rail may be placed as shown on Standard Drawing D-764-3B. The speeds on the main roadway shall be 55 mph or less and the 750 ADT or less.

e. Where roadside constraints, such as drainage, do not allow for flaring the guardrail at the rate based on design speed (9:1 - 40 mph, 10:1 - 45 mph, 11:1 - 50 mph, 12:1- 55 mph, 13:1 - 60 mph, 14:1 - 65 mph, 15:1 - 70 mph, and 16:1 - 75 mph), the guardrail should be installed straight using w-beam guardrail . A straight section should be installed and attached to the bridge rail as shown on Standard Drawing D-764-3. The required W-Beam guardrail length of need requirement should be design as specified section III-13-07.1

If an approach is encountered in this length, it should be treated as stated above, except if approach cannot be moved and is within the length of need, some other method should be determined for providing the guardrail need should be found (possibly obtaining right of way to provide for drainage around the flared fill).

f. For length of guardrail needed for retrofit bridge rail, the same method is used as stated above, except the double W-beam guardrail at the bridge end should be replaced by the Thrie Beam to W-beam section.

5. Flared guardrail will need fill material provided to place the guardrail, as shown on Standard Drawings D-764-9 A through D-764-13. It should be noted that this fill area should be installed from the graded shoulder to 3' behind the guardrail, and this area should be 10:1 or flatter. The foreslope in advance of the end treatment should be equal to the foreslope it is matching. The foreslope behind the guardrail between the end treatment and the bridge may be steepened to accommodate the fill.

6. Where guardrail is provided on divided highway bridges, the guardrail length is determined as stated above. The distance from the approach roadway centerline to the bridge rail face, times two, should be the clear roadway width of the bridge. Use this and the traffic volumes.

III–13.09.2 Obstacles. The designer should use the guardrail type, dependent on guardrail offset from the roadway driving lane and the clear distance from the obstacle.
The W-beam guardrail should be flared, if possible. All obstacles should have a minimum of 25' of straight guardrail in advance of the obstruction and 25' past, except on divided highways, the length past the obstacle can be reduced to 12'-6" when a cable anchor is installed. 3-cable guardrail should not be placed on the inside of curves with curvature of more than 4 degrees. Intermediate anchors should be installed as specified on Standard drawing D.